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Field Evaluation of Insecticides for Control of Turfgrass Insect Pests in West Virginia – 1969-1976

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Field Evaluation of Insecticides for Control of Turfgrass Insect Pests in West Virginia — 1969-1976

Joseph E. Weaver

The major insect pests of turfgrass in West Virginia during the period covered by this report were the hairy chinch bug, *Blissus leucopterus hirtus* Montandon (Hemiptera; Lygaeidae), a sod webworm, *Pediasia trisecta* (Walker) (Lepidoptera: Pyralidae: Crambinae) and various species of white grubs (Coleoptera: Scarabaeidae). The most common white grub was the Japanese beetle, *Popillia japonica* Newman. Less common of the grubs, but found in numbers high enough to cause damage, were the southern masked chafer, *Cyclocephala immaculata* (Oliver), the green June Beetle, *Cotinus nitida* (L.) and *Ataenius spretulus* (Haldeman). White grubs of the genus *Phyllophaga* were only occasionally encountered.

No reports on control of turfgrass insect pests in West Virginia have appeared in recent years, and, in general, there have been only a relatively few reports of field evaluations of insecticides for control of turfgrass pests in the eastern United States. During the last five to ten years, several new organophosphate and carbamate insecticides have been developed and made available for field testing. Some of these show promise for controlling chinch bugs, sod webworm and/or white grubs, and some are effective against all three pests. Many of these organophosphate and carbamate compounds are much less persistent than the cyclodiene insecticides (e.g., chlordane and dieldrin) that have been widely used to control turfgrass insects. There also has been an increasing effort by researchers and manufacturers to expand labels on insecticides registered for other uses to include pests of turfgrass.

Resistance to insecticides is a continuing problem in insect control and occurs most frequently in insect populations subjected to repeated insecticidal treatments. Resistance to cyclodiene insecticides in Japanese beetle has been reported in Ohio (Niemczyk and Lawrence 1973, Niemczyk 1975), New York (Tashiro and Neuhauser 1973), and Connecticut (Dunbar and Beard 1975). These findings illustrate the importance of continued evaluation of insecticides for control of turfgrass insects so that a number of compounds will be available to combat resistant populations.

Additionally, insects previously considered of "minor" importance in turfgrass may assume the status of major pests when conditions favor the buildup of large populations. Control methods and chemicals have to be evaluated to combat these pests. A new problem with one such minor pest, *Ataenius spretulus* (Haldeman), has recently occurred in eastern and midwestern states. *A. spretulus* is a grub pest of turfgrass and was responsible for severe damage (primarily to golf course turf) in some sections of West Virginia in 1975 and 1976. Studies have been initiated to investigate the life history and habits of this insect in the state and to evaluate methods of control.

Field evaluations of insecticides for control of turfgrass insect pests were begun in 1969 after reports were received of severe damage occurring on lawns in the Morgantown area. Upon investigation, the primary insect responsible for this damage was the hairy chinch bug, but many lawns were also found infested with sod webworm. Beginning in 1971, the study was expanded to include evaluation of insecticides for white grub control. During these studies, 21 chemicals in 43 formulations were tested at various rates for control efficacy. This publication presents the results of these tests from 1969 to 1976.

METHODS AND MATERIALS

The insecticides evaluated were: acephate (Orthene*), carbaryl (Sevin*), carbofuran (Furadan*), chlordane, chlorpyrifos (Dursban*), diazinon, fensulfothion (Dasanit*), fonofos (Dyfonate*), metalkamate (Bux*), methomyl (Lannate*), phosmet (Imidan*), pirimiphos-ethyl (Primicid*), pirimiphos-methyl (Actellic*), propoxur (Baygon*), propyl thiopyrophosphate (Aspon*), trichlorfon (Dylox*), and the following compounds that do not have approved common names; CIBA-Geigy CGA-12223 (O-[5-chloro-1-(1-methylethyl)-1H-1,2,4-triazol-3-yl] O,O-diethyl phosphorothioate), Plant Protection Ltd. PP 484 (di-ethyl 2-ethylacetamido-6-methyl pyrimidin-4-yl phosphorothionate), Stauffer R-20458 ((E)-6, 7-epoxy-1-(p-ethylphenoxy)-3,7-dimethyl-2-octene), Thompson-Hayward TH-6040 (1-(4-chlorophenyl)-3-(2,6-difluorobenzoyl)-urea), and Union Carbide UC-21865 (2 methyl-2-(methylsulfonyl) propionaldehyde O-(methylcarbamoyl) oxime. The latter three are insect growth regulators.

A soil analysis from the test areas showed the following percentages of sand, silt and clay, respectively: University lawn, 22 percent, 52 percent, and 26 percent; University golf course, 25 percent, 60 percent, and 15 percent. No analysis was made of the soil from private lawns, but percentages of sand, silt and clay probably would not differ greatly from those of the University.

The grass species in the test areas were primarily one of the Kentucky bluegrasses; most private lawns were planted with Merion bluegrass. There was little or no thatch in the test areas at the University and no more than 0.25 to 0.5 inches of thatch in private lawns.

Chinch Bug Control

1969 Experiments

Test plots for chinch bug control were established on three private lawns in the Morgantown area. Plot size varied from 180 to 750 ft.^{2} depending upon the

*Registered trademark.

number of treatments and lawn size. Treatments were not replicated in individual lawns, but each treatment, except for carbaryl at two rates, was applied in at least two of the three lawns.

Applications of granular formulations were made with a broadcast fertilizer spreader; liquid and wettable powder formulations were applied with a hose proportioner sprayer at the rate of 1-2 gal. water per 100 ft.^{2} of lawn surface. After application, treatments were watered in with 3-5 gal. water per 100 ft.^{2}. Lawns were usually cut a day or two before treatment.

Chinch bug populations were sampled by flooding the insects to the surface in a cylinder embedded in the soil as suggested by Brogdon and Kerr (1965). The cylinder enclosed an area of 0.2 ft.^{2}. All chinch bugs floating to the surface during a 5-minute period were collected and counted. Two samples were taken in each plot. Areas sampled were never closer than 3-4 feet to plot boundaries and were taken in areas which showed signs of damage when it was present.

1970 Experiments

Test plots were established on two private lawns in May and June. Plot size ranged from 220 to 375 ft.^{2}. Treatments were replicated twice in Lawn No. I but were unreplicated in the other lawn.

Only liquid and wettable powder formulations were evaluated in 1970. These formulations were applied with a hose proportioner sprayer at the rate of 1-2 gal. water per 100 ft.^{2} as in 1969, but were watered in at a lower rate of 2-3 gal. of water per 100 ft.^{2}.

Sampling for chinch bug was conducted the same as in 1969.

1971, 1974 and 1976 Experiments

Plots were established on lawn areas of the University grounds. Plots were 10 ft. x 10 ft. replicated three times in a randomized complete block design.

Liquid and powder formulations were applied in 1 gal. water with a hose proportioner sprayer or with a sprinkling can; treatments were watered in with 1 additional gal. in 1971 and 1974 and with 3 gal. in 1976. Granules were applied with a hand shaker and watered in with 2 gal. per plot in 1971 and 1974 and 3 gal. in 1976.

Chinch bug populations were sampled as in previous experiments but each plot was sampled only once each sampling date.

White Grub Control

1971 - 1975 Experiments

Test plots were established on University grounds both on lawn areas and fairway rough of the golf course. Plot size in all experiments was 10 ft. x 10 ft. Treatments in the spring applications of 1971 were replicated twice, while all others were replicated three times in a randomized complete block design.

Liquid and powder formulations were applied with a hose proportioner sprayer and sprinkling can. Amounts of water used per plot for application and watering in respectively were: 1971, 1 gal. plus 2 gal.; 1972-1973, 1 gal. plus 3 gal.; 1974 and 1975, 1 gal. plus 2 gal. Granules were applied with a hand shaker and watered in at the same rate as other treatments. In the 1972-73 experiments, various watering in regimes were also investigated; after application, certain chemicals were (1) left unwatered, (2) watered in at the "standard" rate of 3 gal., and (3) watered in at a higher rate of 16 gal. per 100 $ft.^2$.

White grub populations were sampled by digging up 1 $ft.^2$ of soil to a depth of 2-3 inches; one sample was taken in the center of each plot. The grubs from each sample were collected and identified later.

RESULTS AND DISCUSSION

Interpretation of the results of these studies is based on the following subjective categories assigned for control evaluation calculated as percentage reduction of the insect population: excellent 86-100%, good 71-85%, fair 56-70%, poor <56%.

Rates of application in pounds active ingredient per acre are listed after each compound. Compound formulations have been abbreviated as follows: EC = emulsifiable concentrate, F = flowable, G = granular, LS = liquid solution, SC = soluble concentrate, SP = soluble powder, and WP = wettable powder. HYDRO-WET is a soil and turf wetting agent manufactured by Kalo Laboratories, Inc., Kansas City, Missouri. In discussing control in terms of weeks posttreatment, the term posttreatment has been abbreviated to PT.

Chinch Bug Control

1969 (Table 1)

The first application of trichlorfon 5G + pyrethrin 0.044% at 5 & 8 lb. gave poor to fair control in Lawn I and excellent control in Lawn II at 10 weeks PT. After the second application, nearly 100% control was achieved except for the 8 lb. rate in Lawn I.

Trichlorfon 5G at 5 & 8 lb. gave excellent control throughout the test in Lawn II, but results were variable, from poor to excellent, in Lawn I. The second treatment provided good to excellent control at 2 and 4 weeks PT.

Trichlorfon 4EC + pyrethrin 0.38% at 2 & 4 lb. gave generally excellent control in all lawns at 4 weeks PT. Results were variable for the 6 and 8 lb. rates applied in August in Lawn I providing control only at the 2 weeks PT sampling date; in Lawn II excellent control was obtained up to 4 weeks PT.

Trichlorfon 4LS at 2 &4 lb. gave good to excellent control at 4 weeks PT in Lawns I and II, but results were variable in Lawns II and III after the second application. Only the 4 lb. rate gave any control at 7 weeks PT in Lawn III. At the 6 & 8 lb. rates results were variable (poor to good) in Lawn I at 2 and 5 weeks PT, but excellent control was achieved in Lawn II at 4 weeks PT.

Carbaryl 50 WP at 4 & 8 lb. in Lawn I provided excellent control 2, 4 and 5 weeks PT. Results were variable in Lawn III, but after the second application the 4 lb. rate gave excellent control 4 weeks PT.

Carbofuran 75WP at 1 & 2 lb. gave good to excellent control in Lawn II at 2 and 4 weeks PT. In Lawn III no control was achieved until after the second application when only the 2 lb. rate gave excellent control.

1970 (Table 2)

Trichlorfon 4EC + pyrethrin 0.38% was tested only at the 8 lb. rate since results were poor or inconsistent at lower rates tested in 1969. Excellent control was achieved up to 8 weeks PT in both lawns, but at 10 weeks PT good control was provided in Lawn I only. The population in Lawn I, however, was much higher than in Lawn II.

Trichlorfon 4LS was tested only at the 8-lb. rate for the same reasons as the 4EC pyrethrin mix and gave similar results. Except for the initial application in Lawn II when no control was achieved at 4 weeks PT, the treatment gave excellent control at 4 and 10 weeks in Lawn I and at 7 and 8 weeks in Lawn II.

Carbaryl 50WP at 4 lb. gave good to excellent control in both lawns at 3, 7, 8, and 10 weeks PT.

Propoxur 1.5SC at 8 lb. gave excellent control in both lawns on all sampling dates (4, 7, 8, and 10 weeks PT).

Carbofuran 75WP at 2 lb. provided only poor control after one application at 4 weeks PT but gave excellent control at the 10-week sampling date.

1971 (Table 3)

Excellent control was achieved at 4 weeks PT with chlorpyrifos 2.5G, 2 lb., pirimiphos-ethyl 4EC, 8 lb., chlorpyrifos 0.5G on fertilizer, 2 lb., and diazinon 2G, 2 lb. All except diazinon provided excellent control when sampled at 8 weeks.

Good control was provided by propyl thiopyrophosphate 1EC and 3.2% on vermiculite, 7.3 lb., propoxur 70WP, 4.5 lb., pirimiphos-methyl 4EC, 4 & 8 lb., and carbaryl 2.6F, 4 lb. At 8 weeks PT, all gave fair to good control except pirimiphos-methyl 4EC, 4 lb., and carbaryl 2.6F, 4 lb., which gave no control.

Fair control was provided by propoxur 5G, 0.5 lb. and 70WP, 2.25 lb., chlorpyrifos 2EC, 1 lb., and phosmet 50WP, 10 lb. at 4 weeks PT. Only chlorpyrifos gave adequate control at 8 weeks PT.

Pirimiphos-ethyl 4EC, 4 lb., diazinon 2EC, 2 lb., acephate 75SP, 2.5, 5 & 10 lb., fensulfothion 15G, 1.5 lb., and trichlorfon 1LS, 1 lb., provided generally poor or no control at 4 and 8 weeks PT.

1974 (Table 4)

A limited number of compounds were tested in 1974 because chinch bug populations were low and were found in only one small area of University grounds. In these tests, evaluated at 3 weeks PT, excellent control was achieved with pirimiphos-ethyl 5EC, 2 lb., propyl thiopyrophosphate 1EC, 3.7 lb., and 3.2G, 3.7 lb., and CGA-12223 5G, 2 lb. CGA-12223 5G gave nearly excellent control at the 1-lb. rate, but provided only poor control at the 0.5 lb. rate. Pirimiphos-ethyl 5EC gave only fair control at the lower rate of 1 lb.

1976 (Table 5)

Chinch bugs in sufficient numbers were observed in one lawn in 1976 and further data on the efficacy of three compounds were gathered. This infestation was discovered late in the season and the plots were sampled only one time at 3 weeks PT; considerable damage had occurred to the turf in some of the treated and untreated areas at that time and the entire lawn was treated by the owner. Excellent control of chinch bugs in heavily infested areas was provided by CGA-12223 5G and 2E at both the 1 and 2 lb. rates and metalkamate 10G at 12.5 and 15 lb. Methomyl 1.8E did not provide adequate control; only at the higher rate of 1.8 lb. was there any reduction in the population from the untreated check.

White Grub Control

1971 (Table 6)

The following compounds gave excellent control as spring applications: propoxur 70 WP, 2 & 6 lb.; chlorpyrifos 2EC, 2 & 4 lb.; diazinon 2EC, 2, 4, 5.5 & 6.8 lb.; diazinon 2G, 2, 4 & 6 lb.; metalkamate 10G, 15 lb.; chlorpyrifos 2.5G, 4 lb.; and 2EC, 2 lb.; acephate 75SP, 15 lb.; carbaryl 2.6F, 5 & 8.8 lb.; and phosmet 50WP, 10 lb. Excellent control was also achieved in summer applications of diazinon 2EC, 6.8 lb., and 2G, 2 lb., but only fair to good control was provided by diazinon 2EC at 2 & 5.5 lb. Carbaryl 2.6F, 8.8 lb., gave good control as a summer treatment, but phosmet 50WP at 10 lb. provided no control.

Spring applications of the following gave good control: metalkamate 10G, 10 lb.; fensulfothion 15G, 1.5 lb.; and chlorpyrifos 0.5G on fertilizer at 2 & 4 lb. Fensulfothion 15G, 1.5 lb., and chlorpyrifos 2.5G, 2 lb., provided excellent control in summer treatments while the 2 lb. rate of chlorpyrifos 0.5G provided only fair control.

Only fair control was achieved in spring applications with propoxur 5G at 0.5 & 1 lb., chlordane 8EC at 5 lb., acephate 75SP at 20 lb., and trichlorfon 2SC at 6.8 lb.

Chlorpyrifos 0.5G at 4 lb., tested as a spring application, and carbaryl 2.6F at 4 lb., propoxur 5G at 1 lb. and 70WP at 2.25 lb., as summer treatments, gave poor control.

Additional summer applications giving excellent control were metalkamate 4.2G at 12.5 & 15 lb., pirimiphos-ethyl 4EC at 8 lb., and carbofuran 3G at 2 lb. Carbofuran 4F at 2 lb., metalkamate 4.2G at 10 lb., and pirimiphos-methyl 4EC at 8 lb., also gave good control as summer treatments.

1972 (Table 7)

Spring applications giving excellent control were carbaryl 2.6F at 5 lb., and diazinon 2EC at 6.8 lb. Good control was achieved with fonofos 10G at 10 lb. and chlordane 8EC at 5 lb., while only fair control was provided by carbofuran 3G at 2 lb., pirimiphos-ethyl 2EC at 2 lb., chlorpyrifos 2EC at 2 lb., and phosmet 50WP at 10 lb.

The following treatments gave poor control: pirimiphos-ethyl 5G at 1, 2 & 3 lb.; chlorpyrifos 0.5G and 2EC at 2 & 3 lb.; chlorpyrifos 0.5G on fertilizer at 2 & 3 lb.; pirimiphos-ethyl 2EC encapsulated at 2 lb. without extra watering; and chlorpyrifos 2EC at 2 lb. plus HYDRO-WET.

Summer applications that gave excellent control were diazinon 2EC at 5.5 & 6.8 lb., fonofos 10G at 5 & 10 lb., chlordane 8EC at 5 lb., pirimiphos-ethyl 2EC encapsulated at 2 lb., carbofuran 3G at 2 lb., pirimiphos-ethyl 5G at 2 & 3 lb., chlorpyrifos 0.5G at 2 lb., chlorpyrifos 2EC at 3 lb., trichlorfon 4LS at 8 & 16 lb. and 5G at 16 lb., phosmet 50WP at 5 lb., pirimiphos-ethyl 4EC at 4 lb., and propoxur 70WP at 6 lb. Good control was provided by phosmet 50WP at 10 lb., chlorpyrifos 2EC at 2 lb. plus HYDRO-WET, R-20458 4EC at 1 & 4 lb., and trichlorfon 5G at 8 lb. Chlorpyrifos 2EC at 2 lb. and propoxur 70WP at 12 lb. gave poor control.

In general, those compounds tested at different watering rates gave slightly better control at the higher rate of ¼ inch per acre in both spring and summer applications.

1973 (Table 8)

The following compounds gave excellent control in spring applications: fensulfothion 15G at 10.9 & 21.8 lb., diazinon 2EC at 6.8 lb., carbofuran 4F at 2 lb., pirimiphos-ethyl 5EC at 1 lb. and with HYDRO-WET at 2 lb., PP-484 2EC at 4 lb., fonofos 10G at 5 lb., trichlorfon 5G at 8 lb., and CGA-12223 5G at 2 & 6 lb. Good control was achieved with propoxur 5G at 5.5 lb., phosmet 50WP at 5 lb., and pirimiphos-ethyl 5EC at 2 lb. at the higher watering rate. Compounds giving only fair control were propoxur 5G at 8 lb., trichlorfon 5G at 5.5 lb., chlorpyrifos 2EC at 2 lb., and pirimiphos-ethyl 5EC at 2 lb. Propoxur 70WP at 5.5 & 8 lb., PP-484 2EC at 2 lb., pirimiphos-ethyl 5EC at 1 lb. plus HYDRO-WET, carbofuran 4F at 2 lb., and chlorpyrifos 2EC at 2 & 4 lb. gave poor control.

Watering at a higher rate or not watering after application did not influence the efficacy of these compounds except pirimiphos-ethyl whose efficacy was slightly enhanced.

Summer applications giving excellent control were fensulfothion 15G at 10.9 & 21.8 lb., PP-484 2EC at 4 lb., CGA-12223 5G at 6 lb., carbofuran 4F at 2 lb., and diazinon 8EC at 6.8 lb. Compounds that were rated as giving good control were carbofuran 4F at 2 lb., pirimiphos-ethyl 5EC at 2 lb. at the high watering rate and without watering after application, chlorpyrifos 2EC at 2 & 4 lb., propoxur 70WP at 5.5 lb., CGA-12223 5G at 2 lb., pirimiphos-ethyl 5EC at 2 lb.

with standard watering, propoxur 70WP at 8 lb., and diazinon 8EC at 6.8 lb. All but the last four compounds gave nearly excellent control of the grub population.

Fair control was provided by trichlorfon 5G at 8 lb., while only poor or no control was afforded by propoxur 5G at 5.5 & 8 lb., trichlorfon 5G at 5.5 lb., chlorpyrifos 2EC at 2 lb. with standard watering and, diazinon 8EC at 6.8 lb. without watering.

1974 (Table 9)

Evaluation of summer applications were the only tests conducted in 1974. Excellent control was achieved with CGA-12223 5G at 0.5, 1 & 2 lb., fonofos 5G at 5 lb. and 4EC at 4 lb., fensulfothion 15G at 3 & 5 lb., pirimiphos-ethyl 5EC at 2 lb., and carbofuran 4F at 2 lb. Diazinon 8EC at 6.8 lb., and fonofos 5G at 4 lb. and 4EC at 5 lb. gave good control. Fair control was achieved with the lower rate, 3 lb., of fonofos 5G and 4EC. R-20458 gave only poor control.

1975 (Table 10)

Only spring applications were evaluated in 1975. Compounds giving excellent control were CGA-12223 1G at 2 lb. and the 4EC at 0.75 lb. and 2 lb. Good control was achieved with CGA-12223 2E at 1 lb., and diazinon 4EC at 5 lb. Only fair control was provided by CGA-12223 1G at 0.75 lb. and TH-6040 25WP at 0.125 lb. There was no control with CGA-12223 1G at 1 lb., TH-6040 25WP at 0.5 lb., carbofuran 4F at 2 lb., or UC-21865 75WP at 6 lb.

SUMMARY AND CONCLUSIONS

The efficacy of a compound applied for turfgrass insect control cannot be adequately evaluated on the basis of only one or two seasons of field tests. Weekly variations in rainfall and temperature during the trial period from year to year influence the control provided by a compound. Insect abundance, i.e., high or low populations, in the turf or soil also appears to influence the results provided by some compounds. Thus, in summarizing the results of this study, compounds that are listed as giving the best control are those that were most consistent in providing good to excellent control in all tests.

The compounds that gave the best overall control of chinch bug were carbaryl 50WP, carbofuran 75WP, chlorpyrifos 0.5 & 2.5G, CGA-12223 5G (at the higher rates), diazinon 2G, pirimiphos-ethyl 4 & 5EC (at the higher rates), propoxur 1.5SC and trichlorfon 5G, 4EC & 4LS. Two other compounds, propyl thiopyrophosphate 3.2G & 1EC and propoxur 70WP, were promising. Although trichlorfon is listed as one of the better compounds, it did not appear to have as much residual effect as many of the other compounds; in lawns with high chinch bug populations, a second application was often necessary for adequate control.

The compounds that gave the best control of white grubs in both spring and summer applications were CGA-12223 (EC and G), diazinon (EC and G), fensulfothion (G), metalkamate (G), and PP-484 (EC at the highest rate). Results were inconsistent with phosmet (WP) (poor to excellent) and chlordane (EC) (fair to excellent). Carbofuran (F and G) was best when applied in summer. Fonofos (EC and G), in the summer tests, provided good to excellent control at the higher rates. Trichlorfon (LS and G) at higher rates performed better in summer applications. Carbaryl F was best when applied in the spring at higher rates. Results with pirimiphos-ethyl (EC and G) were more inconsistent, but, in general, this compound provided best control at the highest rates when applied in the summer.

In those tests of 1972 and 1973 where different watering regimes were investigated, the results were not conclusive. What effect the solubilities of the compounds may have had on the results is not readily apparent from these tests. The water solubilities of carbofuran, diazinon, chlorpyrifos and pirimiphos-ethyl are 700, 40, 2 and 1 ppm, respectively. In general, the effectiveness of pirimiphos-ethyl appeared to be enhanced at the higher rate (¼ acre inch) of watering. Chlorpyrifos, in contrast, was more effective when left unwatered or watered in at the 1/20 acre inch rate. Results were more variable with carbofuran and diazinon, but both tended to be more effective at the normal rate of 1/20 acre inch of watering. For ease of comparison, the results obtained with these compounds at the various watering rates are summarized in Table 11.

Table 1
Efficacy of various insecticides applied for control of the hairy chinch bug—1969.

Insecticide formulation	Lb AI/acre	Treatment date	% Reduction from control on									
				6/20		7/17		8/13		8/29		9/18
Lawn No. I												
Trichlorfon 5G + pyrethrins 0.044%	5.0	5/6,7/17	6[a]	0	10	58	4	95		—		—
	8.0	"		0		26		76		—		—
Trichlorfon 5G	5.0	"		100		0		95		—		—
	8.0	"		0		58		76		—		—
Trichlorfon 4EC + pyrethrins 0.38%	2.0	6/20,7/17		—	4	95		51		—		—
	4.0	"		—		79		39		—		—
	6.0	8/15		—		—		—	2	86	5	0
	8.0	"		—		—		—		73		29
Trichlorfon 4LS	2.0	6/20,7/17		—		74		100		—		—
	4.0	"		—		79		93		—		—
	6.0	8/15		—		—		—		71		25
	8.0	"		—		—		—		36		75
Carbaryl 50WP	4.0	6/20,7/17,8/15		—		100		98		98		93
	8.0	"		—		100		98		96		100
(Avg. no. chinch bugs/ft.^{2} in untreated controls)				(2.5)		(47.5)		(262.5)		(130.0)		(70.0)
Lawn II												
Trichlorfon 5G + pyrethrins 0.044%	5.0	5/6,7/31	6	100	10	100	2	92		—		—
	8.0	"		100		100		100		—		—
Trichlorfon 5G	5.0	"		100		100		100		—		—
	8.0	"		100		100		100		—		—

Trichlorfon 4EC + pyrethrins 0.38%	2.0	6/23,7/31	—	100	38	—	—
	4.0	″	—	100	77	—	—
	6.0	8/20	—	—	—	—	100
	8.0	″	—	—	—	—	100
Trichlorfon 4LS	2.0	6/23,7/31	—	4 100	2 31	—	—
	4.0	″	—	100	100	—	4 —
	6.0	8/20	—	—	—	—	100
	8.0	″	—	—	—	—	100
Carbofuran 75WP	1.0	6/23,7/31,8/20	—	78	100	—	100
	2.0	″	—	97	100	—	100
(Avg. no. chinch bugs/ft.^{2} in untreated controls)			(105.0)	(92.5)	(32.5)	—	(62.5)
Lawn No. III							
Trichlorfon 4EC + pyrethrins 0.38%	2.0	6/24,8/21	—	—	0	—	88
	4.0	″	—	—	0	—	100
Trichlorfon 4LS	2.0	″	—	—	0	—	29
	4.0	″	—	—	60	—	100
Carbaryl 50WP	2.0	″	—	—	80	—	0
	4.0	″	—	—	7 0	—	4 100
Carbofuran 75WP	1.0	″	—	—	0	—	29
	2.0	″	—	—	0	—	100
(Avg. no. chinch bugs/ft.^{2} in untreated controls)			—	—	(25.0)	—	(17.5)

[a] Approximate number of weeks posttreatment.

Table 2
Efficacy of various insecticides applied for control of the hairy chinch bug—1970.

						% Reduction from control on		
Insecticide formulation	Lb AI/acre	Treatment date		6/22		7/18		9/3
		Lawn No. I[a]						
Propoxur 1.5SC	8.0	6/22		—	4[c]	96	10	99
Trichlorfon 4LS	8.0	"		—		91		87
Trichlorfon 4EC + pyrethrins 0.38%	8.0	"		—		87		81
Carbaryl 50WP	4.0	"		—		78		100
Carbofuran 75WP	2.0	"		—		39		99
(Avg. no. chinch bugs/ft.^{2} in untreated controls)				—		(28.8)		(83.8)
		Lawn No. II[b]						
Trichlorfon 4EC + pyrethrins 0.38%	8.0	5/22,7/18	4	100	8	100	7	100
Carbaryl 50WP	4.0	"		100		100		100
Propoxur 1.5SC	8.0	"		84		100		100
Trichlorfon 4LS	8.0	"		0		100		100
(Avg. no. chinch bugs/ft.^{2} in untreated controls)				(7.5)		(3.8)		(7.5)

[a] Pretreat samples on 6/22 averaged 55.0 chinch bugs per ft.^{2}

[b] Pretreat samples on 5/22 averaged 5.0 chinch bugs per ft.^{2}

[c] Approximate number of weeks posttreatment.

Table 3
Efficacy of various insecticides applied for control of the hairy chinch bug—1971.

Insecticide formulation	Lb AI/acre	% Reduction from control at weeks posttreatment[a] 4	6
Chlorpyrifos 2.5G	2.0	100	96
Pirimiphos-ethyl 4EC	8.0	100	100
Chlorpyrifos 0.5G + 12-12-12 fertilizer	2.0	92	98
Diazinon 2G	2.0	88	0
Propyl thiopyrophosphate 1EC	7.3	83	62
Propoxur 70WP	4.5	83	74
Pirimiphos-methyl 4EC	4.0	83	0
Pirimiphos-methyl 4EC	8.0	79	66
Carbaryl 2.6F	4.0	75	0
Propyl thiopyrophosphate 3.2% on vermiculite	7.3	71	62
Propoxur 5G	0.5	67	0
Propoxur 70WP	2.25	67	16
Chlorpyrifos 2EC	1.0	62	86
Phosmet 50WP	10.0	62	22
Pirimiphos-ethyl 4EC	4.0	46	68
Diazinon 2EC	2.0	38	44
Acephate 75SP	5.0	12	0
Acephate 75SP	10.0	4	4
Acephate 75SP	2.5	0	4
Fensulfothion 15G	1.5	0	0
Trichlorfon 1LS	1.0	0	0
(Avg. no. chinch bugs/ft.^{2} in untreated controls)		(40.0)	(83.3)

[a] Treatments applied 7/15.

Table 4
Efficacy of various insecticides applied for control of the hairy chinch bug—1974.

Insecticide formulation	Lb AI/acre	% Reduction from control at 3 weeks posttreatment[a]
Pirimiphos-ethyl 5EC	2.0	100
Propyl thiopyrophosphate 1EC	3.7	92
Propyl thiopyrophosphate 3.2G	3.7	92
CGA-12223 5G	2.0	92
CGA-12223 5G	1.0	83
Pirimiphos-ethyl 5EC	1.0	67
CGA-12223 5G	0.5	42
(Avg. no. chinch bugs/ft.^{2} in untreated controls)		(20.4)

[a] Treatments applied 8/14.

Table 5
Efficacy of various insecticides applied for control of the hairy chinch bug—1976.

Insecticide formulation	Lb AI/acre	% Reduction from control at 3 weeks posttreatment[a]
Metalkamate 10G	12.5	100
Metalkamate 10G	15.0	100
CGA-12223 2E	2.0	100
CGA-12223 2E	1.0	100
CGA-12223 5G	2.0	100
CGA-12223 5G	1.0	95
Methomyl 1.8E	1.8	26
Methomyl 1.8E	0.9	0
(Avg. no. chinch bugs/ft.^{2} in untreated controls)		(101.8)

[a] Treatments applied 9/1.

Table 6

Efficacy of various insecticides applied for control of white grubs—1971.

Insecticide formulation	Lb AI/acre	% Reduction from control Spring application 4 weeks posttreatment[a]	 Summer application 8 weeks posttreatment[b]
Propoxur 70WP	2.0	100	—
Chlorpyrifos 2EC	4.0	100	—
Diazinon 2EC	2.0	100	69
Diazinon 2EC	4.0	100	—
Diazinon 2G	2.0	100	100
Diazinon 2G	4.0	100	—
Diazinon 2G	6.0	94	—
Diazinon 2EC	6.8	94	90
Metalkamate 10G	15.0	94	—
Chlorpyrifos 2.5G	4.0	94	—
Acephate 75SP	15.0	88	—
Diazinon 2EC	5.5	88	83
Carbaryl 2.6F	5.0	88	—
Carbaryl 2.6F	8.8	88	81
Phosmet 50WP	10.0	88	0
Propoxur 70WP	6.0	88	—
Chlorpyrifos 2EC	2.0	88	—
Metalkamate 10G	10.0	82	—
Fensulfothion 15G	1.5	82	100
Chlorpyrifos 0.5G	2.0	82	69
Chlorpyrifos 2.5G	2.0	76	98
Chlorpyrifos 0.5G + 12-12-12 fertilizer	2.0	76	—

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Table 6 *(continued)*

Insecticide formulation	Lb AI/acre	% Reduction from control	
		Spring application 4 weeks posttreatment[a]	Summer application 8 weeks posttreatment[b]
Chlorpyrifos 0.5G + 12-12-12 fertilizer	4.0	76	—
Propoxur 5G	1.0	70	36
Chlordane 8EC	5.0	64	—
Acephate 75SP	20.0	59	—
Trichlorfon 2SC	6.8	59	—
Propoxur 5G	0.5	59	—
Chlorpyrifos 0.5G	4.0	53	—
Metalkamate 4.2G	12.5	—	100
Pirimiphos-ethyl 4EC	8.0	—	100
Metalkamate 4.2G	15.0	—	94
Carbofuran 3G	2.0	—	94
Carbofuran 4F	2.0	—	84
Metalkamate 4.2G	10.0	—	81
Pirimiphos-methyl 4EC	8.0	—	81
Carbaryl 2.6F	4.0	—	13
Propoxur 70WP	2.25	—	0
(Avg. no. white grubs/ft.^{2} in untreated controls)		(8.5)	(17.3)

[a] Treatments applied 5/3.

[b] Treatments applied 7/21.

Table 7

Efficacy of various insecticides applied for control of white grubs—1972.

Insecticide formulation	Lb AI/acre	% Reduction from control Spring application 4 weeks posttreatment[a]	Summer application 7 weeks posttreatment[b]
Carbaryl 2.6F	5.0	93	—
Diazinon 2EC	6.8	91	98
Diazinon 2EC	6.8	88[c]	—
Fonofos 10G	10.0	75	99
Chlordane 8EC	5.0	72	97
Carbofuran 3G	2.0	69[c]	—
Pirimiphos-ethyl 2EC encapsulated	2.0	65[c]	91[c]
Carbofuran 3G	2.0	63	98
Diazinon 2G	2.0	60	—
Chlorpyrifos 2EC	2.0	60	57
Pirimiphos-ethyl 5G	2.0	56[c]	100[c]
Phosmet 50WP	10.0	56	85
Pirimiphos-ethyl 5G	3.0	53	100
Chlorpyrifos 0.5G	2.0	25	89
Chlorpyrifos 2EC	3.0	22	94
Chlorpyrifos 0.5G + 12-12-12 fertilizer	2.0	22	—
Chlorpyrifos 0.5G	3.0	19	79
Pirimiphos-ethyl 5G	1.0	16	35
Chlorpyrifos 2EC	2.0	16[c]	65[c]
Chlorpyrifos 0.5G + 12-12-12 fertilizer	2.0	9[c]	—
Pirimiphos-ethyl 5G	2.0	0	97
Pirimiphos-ethyl 2EC encapsulated	2.0	0	86

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Table 7 *(continued)*

Insecticide formulation	Lb AI/acre	% Reduction from control	
		Spring application 4 weeks posttreatment[a]	Summer application 7 weeks posttreatment[b]
Chlorpyrifos 2EC + HYDRO-WET^{R} (2 gal/acre)	2.0	0	83
Chlorpyrifos 0.5G	2.0	0[c]	86[c]
Chlorpyrifos 0.5G + 12-12-12 fertilizer	3.0	0	–
Trichlorfon 4LS	8.0	–	100
Fonofos 10G	5.0	–	100
Diazinon 2EC	5.5	–	99
Phosmet 50WP	5.0	–	98
Pirimiphos-ethyl 4EC	4.0	–	97
Trichlorfon 4LS	16.0	–	96
Pirimiphos-ethyl 5G	2.0	–	88[d]
Propoxur 70WP	6.0	–	88
Trichlorfon 5G	16.0	–	88
R-20458 4EC	4.0	–	85
R-20458 4EC	1.0	–	83
Chlorpyrifos 2EC	2.0	–	78[d]
Trichlorfon 5G	8.0	–	73
Propoxur 70WP	12.0	–	57
(Avg. no. white grubs/ft.^{2} in untreated controls)		(10.7)	(30.7)

[a] Treatments applied 5/1.

[b] Treatments applied 8/9.

[c] Watered in at rate of 1/4 inch per acre.

[d] Unwatered after application.

Table 8
Efficacy of various insecticides applied for control of white grubs—1973.

Insecticide formulation	Lb AI/acre	% Reduction from control Spring application 4 weeks posttreatment[a]	Summer application 6 weeks posttreatment[b]
Fensulfothion 15G	21.8	100	100
Fensulfothion 15G	10.9	100	100
Diazinon 2EC	6.8	100[d]	–
Diazinon 2EC	6.8	100	–
Carbofuran 4F	2.0	95	85
Carbofuran 4F	2.0	95[d]	30[d]
Pirimiphos-ethyl 5EC	1.0	95	30
Pirimiphos-ethyl 5EC + HYDRO-WET^{R} (1 gal/acre)	2.0	95[d]	–
PP-484 2EC	4.0	95	100
Fonofos 10G	5.0	95	–
Diazinon 2EC	6.8	95[c]	–
Trichlorfon 5G	8.0	90	57
CGA-12223 5G	2.0	90	72
CGA-12223 5G	6.0	90	94
Pirimiphos-ethyl 5EC + HYDRO-WET^{R} (1 gal/acre)	2.0	90	–
Propoxur 5G	5.5	75	43
Pirimiphos-ethyl 5EC	2.0	75[c]	85[c]
Phosmet 50WP	5.0	75	–
Propoxur 5G	8.0	70	36
Trichlorfon 5G	5.5	66	0

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Table 8 *(continued)*

Insecticide formuation	Lb AI/acre	% Reduction from control	
		Spring application 4 weeks posttreatment[a]	Summer application 6 weeks posttreatment[b]
Pirimiphos-ethyl 5EC	2.0	66	79
Pirimiphos-ethyl 5EC	2.0	60[d]	85[d]
Chlorpyrifos 2EC	2.0	60[d]	85[d]
PP-484 2EC	2.0	45	—
Propoxur 70WP	5.5	40	85
Propoxur 70WP	8.0	36	72
Pirimiphos-ethyl 5EC + HYDRO-WET^{R} (1 gal/acre)	1.0	30	—
Carbofuran 4F	2.0	21[c]	100[c]
Chlorpyrifos 2EC	2.0	10[c]	85[c]
Chlorpyrifos 2EC	4.0	0	85
Chlorpyrifos 2EC	2.0	0	43
Diazinon 8EC	6.8	—	94
Diazinon 8EC	6.8	—	79[c]
Diazinon 8EC	6.8	—	21[d]
(Avg. no. white grubs/ft.^{2} in untreated controls)		(6.7)	(4.7)

[a] Treatments applied 5/7.

[b] Treatments applied 8/6.

[c] Watered in at rate of 1/4 inch per acre.

[d] Unwatered after application.

Table 9
Efficacy of various insecticides applied for control of white grubs 1974.

Insecticide formulation	Lb AI/acre	% Reduction from control Summer application 7 weeks posttreatment[a]
CGA-12223 5G	2.0	100
Fonofos 5G	5.0	100
Fonofos 4EC	4.0	100
Fensulfothion 15G	3.0	100
Fensulfothion 15G	5.0	100
Pirimiphos-ethyl 5EC	2.0	90
CGA-12223 5G	0.5	90
CGA-12223 5G	1.0	90
Carbofuran 4F	2.0	90
Fonofos 5G	4.0	77
Fonofos 4EC	5.0	77
Diazinon 8EC	6.8	77
Fonofos 5G	3.0	67
Fonofos 4EC	3.0	67
R-20458 4EC	4.0	43
(Avg. no. white grubs/ft.^{2} in untreated controls)		(3.0)

[a] Treatments applied 8/13.

Table 10
Efficacy of various insecticides applied for control of white grubs 1975.

Insecticide formulation	Lb AI/acre	% Reduction from control Spring application 4 weeks posttreatment[a]
CGA-12223 1G	2.0	100
CGA-12223 2E	0.75	100
CGA-12223 2E	2.0	100
CGA-12223 2E	1.0	82
Diazinon 4EC	5.0	82
CGA-12223 1G	0.75	59
TH-6040 25WP	0.125	59
CGA-12223 1G	1.0	0
Carbofuran 4F	2.0	0
UC-21865 75WP	6.0	0
TH-6040 25WP	0.5	0
(Avg. no. white grubs/ft.^{2} in untreated controls)		(1.7)

[a] Treatments applied 5/5.

Table 11

Efficacy of selected insecticides applied under various watering regimes for control of white grubs 1972 & 1973.

Insecticide formulation	Lb AI/acre	% Reduction from control for treatments applied at indicated time and acre inches of watering											
		Spring					Summer						
		1972		1973			1972			1973			
		1/4	1/20	1/4	1/20	None	1/4	1/20	None	1/4	1/20	None	
Pirimiphos-ethyl 2EC encapsulated	2.0	65	0	—	—	—	91	86	—	—	—	—	
Pirimiphos-ethyl 5EC + HYDRO-WET (1 gal/acre)	2.0	—	—	—	90	95	—	—	—	—	—	—	
Pirimiphos-ethyl 5EC	2.0	—	—	75	66	60	—	—	—	85	79	85	
Pirimiphos-ethyl 5G	2.0	56	0	—	—	—	100	97	88	—	—	—	
Chlorpyrifos 2EC	2.0	16	60	10	0	60	65	57	78	85	43	85	
Chlorpyrifos 0.5G	2.0	0	25	—	—	—	86	89	—	—	—	—	
Chlorpyrifos 0.5G + 12-12-12 fertilizer	2.0	9	22	—	—	—	—	—	—	—	—	—	
Carbofuran 3G	2.0	63	69	—	—	—	—	—	—	—	—	—	
Carbofuran 4F	2.0	—	—	21	95	95	—	—	—	100	85	30	
Diazinon 2EC[a]	6.8	88	91	95	100	100	—	—	—	79	94	21	

[a] 8EC used in summer 1973 treatments.

Literature Cited

Brogdon, James E. and S. H. Kerr. 1965. *Home gardner's lawn insect control guide*. Univ. of Fla. Agr. Ext. Serv. Cir. 213B, 15 pp.

Dunbar, D. M. and R. L. Beard. 1975. *Status of control of Japanese beetle and Oriental beetles in Connecticut.* Conn. Agr. Exp. Sta. Bull. 757:1-5.

Niemczyk, H. D. and K. O. Lawrence. 1973. "Japanese beetle: evidence of resistance to cyclodiene insecticides in larvae and adults in Ohio." *J. Econ. Entomol.* 66:520-521.

Niemczyk, Harry D. 1975. "Status of insecticide resistance in Japanese beetle in Ohio—1974." *J. Econ. Entomol.* 68:583-584.

Tashiro, H. and W. Neuhauser. 1973. "Chlordane-resistant Japanese beetle in New York." N.Y. State Agr. Exp. Sta. (Geneva) Search Agr. 3:6.

APPENDIX

Precipitation at Morgantown, W. Va. 1969-1976.[a]

	Spring application		Summer application	
Year	Date	Precipitation (inches)	Date	Precipitation (inches)
1969	May 6-10	1.91	June 22-28	0.75
	May 11-17	0.26	June 29-July 5	3.43
	May 18-24	0.40	July 6-12	1.74
	May 25-31	0.10	July 13-19	0.87
	June 1-7	0.36	July 20-26	0.90
	June 8-14	0.76	July 27-Aug. 2	1.90
	June 15-21	0.50	Aug. 3-9	1.28
			Aug. 10-16	0.23
	Total	4.29	Aug. 17-23	0.59
			Aug. 24-30	0
			Aug. 31-Sept. 6	0.88
			Sept. 7-13	0.12
			Sept. 14-18	0.21
			Total	12.90
1970	May 22-23	0.24	June 21-27	0.78
	May 24-30	0.24	June 28-July 4	0.75
	May 31-Jun. 6	1.97	July 5-11	1.02
	June 7-13	0.27	July 12-18	1.13
	June 14-20	1.24	July 19-25	0.38
	Total	3.96	July 26-Aug. 1	1.65
			Aug. 2-8	0.19
			Aug. 9-15	0.14
			Aug. 16-22	2.67
			Aug. 23-29	0.27
			Aug. 30-Sept. 3	0.10
			Total	9.08
1971	May 3-8	2.50	July 7-10	0.88
	May 9-15	1.52	July 11-17	0.60
	May 16-22	0.01	July 18-24	1.22
	May 23-29	0.58	July 25-31	2.70
	May 30-31	0	Aug. 1-7	1.04
	Total	4.61	Aug. 8-14	0.14
			Aug. 15-21	0.11
			Aug. 22-28	2.20
			Aug. 29-Sept. 4	0.47
			Sept. 5-9	0.07
			Total	9.43

Appendix *(continued)*

	Spring application		Summer application	
Year	Date	Precipitation (inches)	Date	Precipitation (inches)
1972	May 1-6	1.16	Aug. 9-12	0.14
	May 7-13	0.58	Aug. 13-19	1.58
	May 14-20	1.03	Aug. 20-26	0.07
	May 21-27	0.10	Aug. 27-Sept. 2	0.08
	May 28-30	0.07	Sept. 3-9	0.24
	Total	2.94	Sept. 10-16	0.90
			Sept. 17-19	0.17
			Total	3.18
1973	May 4-5	0	Aug. 4	0
	May 6-12	1.34	Aug. 5-11	0.25
	May 13-19	0.35	Aug. 12-18	1.13
	May 20-26	0.62	Aug. 19-25	0.59
	May 27-Jun.1	1.22	Aug. 26-Sept. 1	0
	Total	3.53	Sept. 2-8	0.31
			Sept. 9-15	1.52
			Total	3.80
1974			Aug. 14-17	0.73
			Aug. 18-24	0.27
			Aug. 25-31	2.80
			Sept. 1-7	2.59
			Sept. 8-14	2.17
			Sept. 15-21	0.70
			Sept. 22-28	0.14
			Sept. 29-Oct. 1	0.18
			Total	9.58
1975	May 5-10	0.28		
	May 11-17	1.72		
	May 18-24	0.92		
	May 25-Jun. 1	0.83		
	Total	3.75		
1976			Sept. 1-4	0.20
			Sept. 5-11	0.46
			Sept. 12-18	0.62
			Sept. 19-21	0.07
			Total	1.35

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[a] Data taken from FAA records at Hart Field except for Summer 1971, Spring 1975, and 1976. Data for those years came from records at Morgantown Lock and Dam.